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Summary: Alzheimer's Disease (AD) and Alzheimer's Disease-Related Dementias (ADRD) are highly prevalent among older individuals throughout the world. The adverse impact of cognitive decline, ranging from mild cognitive impairment (MCI) to AD and ADRD, presents not only a prohibitive financial cost but also physical, mental, and emotional burden to older adults, their caregivers, and society. MCI is a well-established risk factor for AD. However, traditional diagnostic procedures and biomarkers have limited utility in identifying alterations in brain mechanisms that underlie the cognitive decline observed in MCI. While the literature concerning neuroimaging correlates of MCI, AD and ADRD is considerable, traditional brain imaging methods are expensive, restrictive, and typically conducted separately. Moreover, research using multimodal noninvasive neuroimaging methods that can be utilized in naturalistic settings to detect brain-based signatures of MCI has been limited. Developing tools to extract such signatures can lead to the identification of novel biomarkers that can guide the development of precise, and individualized assessment and treatment of age-related cognitive decline and dementia. In this project, we will develop a toolchain for the assessment of MCI using multimodal neuroimaging and machine learning (ML) methods. We propose three specific aims: (1) to develop a comprehensive cognitive testing battery sensitive to MCI in a mobile software synchronized with multimodal functional near infrared spectroscopy and electroencephalography (fNIRS-EEG) based neuroimaging system that can concurrently provide electrophysiological, hemodynamic and behavioral measures; (2) to extract, select, and validate the multitude of within and across modality biomarkers from fNIRS-EEG data in temporal, spatial, spectral, and complexity domains together with the behavioral ones; (3) to develop a comprehensive multimodal ML approach to detect MCI based on fNIRS-EEG and behavioral features. Developing a mobile application that combines fNIRS and EEG on one platform that could be used in less expensive and restrictive testing environments to determine functional brain alterations in older adults with MCI is very innovative. The findings of this project can lead to a transformation in early detection and monitoring of cognitive decline in older adults at risk of developing AD.